European Commission

# Science for Environment Policy

## Silver nanoparticles could pose risk to aquatic ecosystems

**Silver nanoparticles are toxic to common bacteria** at concentrations found in many aquatic environments across the globe, new research has found. Bacteria often form a key part of ecosystems and these impacts may be felt by the entire system, the researchers warn.

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**Source:** Li Matzke, M., Jurkschat, K., & Backhaus, T. (2014). Toxicity of differently sized and coated silver nanoparticles to the bacterium Pseudomonas putida: risks for the aquatic environment? *Ecotoxicology*. 23(5): 818–29. DOI:10.1007/s10646-014-1222-x.

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**Silver nanoparticles** are between one and a hundred nanometres (nm) in size and are now used for their antimicrobial action in a wide range of products, from clothes and cosmetics, to bandages and building materials. As a result, their release to the environment, via waste treatment and industrial processes, is expected to grow.

Silver nanoparticles are antimicrobial because they release silver 'ions' – charged molecules of silver – which interfere with processes in living cells. As a result they have the potential to damage ecologically important bacteria and other microorganisms in soils, or to accumulate through food webs, which could damage the health of larger creatures.

To investigate the environmental risks associated with silver nanoparticles, the researchers examined their toxicity to a common bacterium, *Pseudomonas putida*, found in both rivers and soils.

The study – part-funded by the EU NanoFATE project[1] – examined seven commercially available silver nanoparticles which were of different sizes and coated with citrate, tannic acid or left uncoated. Each nanoparticle type was tested for its ability to inhibit the growth of *P. putida* cultures at a range of concentrations. From this, the researchers determined the concentrations which inhibited the growth of the bacterial cultures by 5, 10 or 50% ($EC_{05}$, $EC_{10}$ and $EC_{50}$). The researchers also assessed the effect of silver nitrate, as a non-nano source of silver ions.

Silver nitrate was the most toxic with $EC_{50}$ and $EC_{05}$ values (inhibiting growth by 50 and 5%) at 0.16 and 0.043 micrograms per litre (µg/L). The greater toxicity of silver nitrate has regularly (although not uniformly) been found in other studies.

The most toxic form of nanoparticle was uncoated 20 nm particles, with $EC_{50}$ and $EC_{05}$ values of 0.25 and 0.13µg/L. Tannic acid coated particles showed intermediate toxicity, (1.03 µg/L and 0.22 µg/L, respectively) and citrate coated particles were the least toxic, with the highest ECs (13.5 µg/L and 3.41 µg/L, respectively). There was no obvious explanation for these differences.

The size of the nanoparticles had no clear effect on toxicity. This is in contrast to other studies, which have suggested that smaller nanoparticles are more toxic. In this study the smallest (8 nm) particle had intermediate levels of toxicity with $EC_{50}$ and $EC_{05}$ values of 3.46 and 0.73 µg/L. The authors argue that it was the rate of ion release, rather than shape or size, which was the driving factor for toxicity.

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1. NanoFATE (Nanoparticle Fate Assessment and Toxicity in the Environment) is supported by the European Commission under the Seventh Framework Programme. See: http://www.nanosafetycluster.eu/eu-nanosafety-cluster-projects/seventh-framework-programme-projects/nanofate.html

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# Silver nanoparticles could pose risk to aquatic ecosystems (continued)

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Total silver ion concentrations in aquatic environments around the world have been reported at levels ranging between 0.1 and 120 µg/L. This spans the range of silver concentrations used in this study. Since silver nitrate, a direct source of silver ions, was the most toxic form, the authors suggest that hazard assessment based on total silver ion concentration (rather than nanoparticle concentration) should provide sufficient protection for the environment.

However, larger creatures could ingest or indirectly take up nanoparticles (through the gills of fish, for example). For these animals the toxicity of silver nanoparticles and silver ions may differ, and as such further research is needed to better assess risks to the environment. It is also important to note that these tests were undertaken in the laboratory, where conditions are carefully controlled and may differ from those in the wild. Furthermore, it is possible that species may be more or less sensitive to silver nanoparticles at different points in their lifecycle.

Research into the toxicity of metal nanoparticles is still in its early stages. For example, more investigations into the effects of these particles on algae, which also play a key role in many ecosystems, are needed to provide a broader picture of the toxicity of these particles to different types of organisms. Further studies are also needed into the influence of different coatings on toxicity, especially as experiments on water fleas (*Daphnids*) and algae have shown that coating could be a driving factor of the toxicity of these particles, either due to silver ion release or effects related to the form itself.